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fMRI of Scanner Noise Induced Auditory Cortex Activation

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PURPOSE:

In this study, cortical regions activated by the acoustic noise of the fMRI scanning process are mapped.

INTRODUCTION:

A major concern in functional MRI (fMRI) studies of the auditory cortex and of cognitive activation is the effect that the noise produced by the scanning process has on baseline neuronal activation state. Regions activated by the scanner noise may not be able to be modulated sufficiently by a given task. This study begins to address this issue by mapping the regions activated by the scanner noise.

METHODS:

All studies were performed using echo planar imaging (EPI) on a Bruker Biospec 3T/60 scanner. A balanced torque three axis gradient coil and endcapped quadrature transmit receive RF coil were used. One to five imaging planes were collected. In-plane voxel dimension = 3.8 x 3.8 mm. Slice thickness = 5 to 10 mm. TE = 27 to 40 ms. TR = 0.3 to 1 sec. FA = 40° to 90°. Four subjects, wearing earplugs, were scanned. Two time series types were collected: An "activation time series" involved first applying only EPI gradients, at the same TR used for imaging, for about 20 seconds without any RF, then, without pause, starting the time series image collection. Images were collected for 20 to 40 seconds. A second "control time series" involved the sequential acquisition of echo planar images in the same manner as the first time series, but without the prior 20 seconds of EPI gradient pulses. For each study, four successive control and activation time series were collected in an interleaved fashion and averaged.

The time dependence of the MR signal during its approach to steady state longitudinal magnetization (the first several seconds of acquisition) was identical in the two time series, *except* in regions that had enhanced blood oxygenation level dependent (BOLD) contrast due to neuronal activation by the prior EPI gradient pulses. The difference in the signal during the first several seconds of image acquisition, (before the hemodynamic response in the "control" time series had time to reach a steady state "on" condition) was used to map activation by the EPI gradient pulses. Each difference image for the first 5 seconds of imaging showed activation the primary auditory cortex. Functional images were created by correlating the first seven seconds of the difference time series (i.e. the time series created by subtraction of the "control" from the "activation" images at each time point) with a reference function obtained from the difference signal in the auditory cortex.

RESULTS:

Figure 1 a shows two plots of the MRI signal (each an average of four time series) from the same ROI in the auditory cortex during the first 12 seconds of imaging. (TE = 40 ms, TR = 500 ms, FA = 60°, slice thickness = 5 mm). The signal from the primary auditory cortex, as it approached steady state longitudinal magnetization, was elevated in the series that had the prior gradient pulses applied. After five seconds of imaging, no significant difference between the two time series was observed. Figure 1 b shows the fractional difference between the "control" time series and the "activation" time series at each time point. The time to reach zero difference in Figure 1 b reflects the latency of the hemodynamic response relative to the onset of the imaging gradient pulses. Figure 2 shows the anatomical echo planar images and corresponding functional images of activation by the scanner noise. Delineation of primary auditory cortex activation is shown.

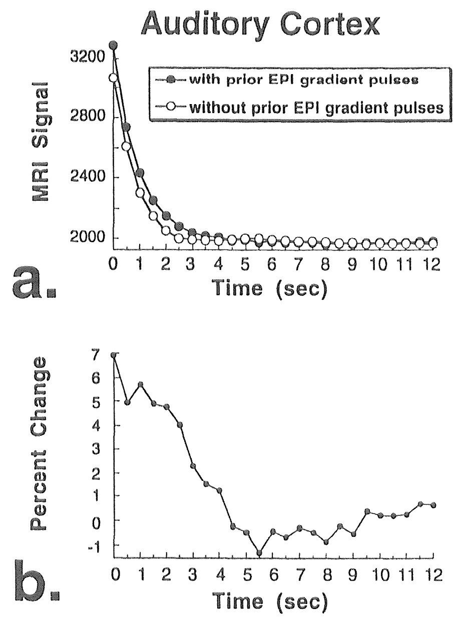

Figure 1: MRI signal from the primary auditory cortex during the first 12 seconds of image acquisition. TR = 500 ms, TE = 40 ms, ø = 60°. **a)** Plots of auditory cortex MRI signal with and without prior gradient pulses. **b)** Plot of the fractional difference between two plots in a.

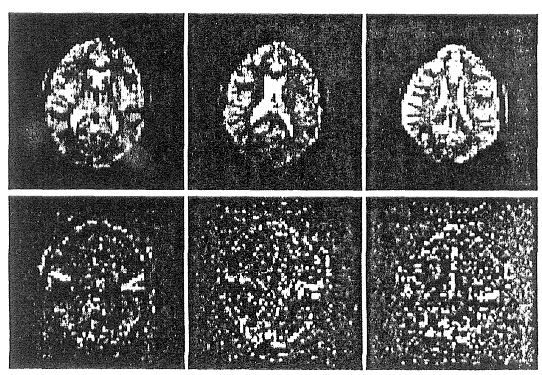

Figure 2: Anatomical images and corresponding functional images of activation by the scanner noise. Activation is shown in the primary auditory cortex.

CONCLUSIONS:

Brain activation produced by the acoustic noise of EPI has been mapped. Future efforts in mapping of the tonotopic representation of the primary auditory cortex may benefit from paradigms designed to take scanner noise related activation into account. An example of a paradigm to use would be one that involves alternating between tone presentation and silence prior to starting each time series collection of images, then performance of analysis of the difference signal from the first 5 seconds of each of these two time series types.